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ABSTRACT

The history of computer-assisted instruction (CAI) courseware is described with specific reference to the PLATO system. Among the goals of courseware authors are finding better ways to develop the cognitive skills of students, to shift some of the burden of routine classroom instruction away from the teacher so that more class time can be spent in more productive activity, and to learn more about the capabilities of computer-assisted instruction. Among the general conclusions that can be drawn about CAI courseware development are: (1) the importance of each individual's awareness of an involvement in the entire project, (2) the creation of fancy displays and animation does not necessarily result in more effective learning, (3) the use of student feedback in the development of courseware generally results in a greater acceptance of the final product, and (4) courseware authors frequently see their lessons as works of art, and they frequently have highly vested interests in them. While the multiplicity of approaches to courseware development has been valuable for the PLATO project, changes in the technology of the system make it difficult to keep all authors apprised of system constraints and enhancements. (DGC)

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The Evolutionary Development of CAI Courseware

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At the time the PLATO III system was developed with its capability of running 20 students simultaneously (1966), there was a considerable body of research literature which apparently could serve as a basis for developing courseware. Even before the application of computers to teaching machines, Skinner (1968) had pointed out some of the unique capabilities of teaching machines but warned that the success of these machines also depended on the material used in them. Psychologists had given considerable attention to the various factors that influence learning in programmed instruction, such as the logic of organization, knowledge of responses, step size, and so on. Educational technologists had begun to apply a systems approach to instructional design. One might expect, therefore, that courseware development for PLATO would follow a prescribed approach. As it turned out, for most disciplines this was not the case. Those who did follow the systems approach found that a number of modifications were necessary when they implemented their programs.

Computer-assisted instruction (CAI) is unique as an educational medium in that it combines the interactive aspects of individualized tutoring with some of the display capabilities of textbooks and television and the computational power of a computer. The PLATO approach to CAI has not been fixed or rigid. Hardware and software staff have made modifications to the system in response to the requests and educational requirements of its users. Because of PLATO's special features and design flexibility one could not assume a priori that a single prescribed approach to instructional design was either suitable or desirable. The first part of this discussion will consider some of the diverse goals that led authors to try different approaches to courseware development. This will be followed by a description of some aspects of the actual procedures followed in developing PLATO curricula. Finally, consideration will be given to what generalizations can be made and what conclusions

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drawn from this early experience.

This paper is not intended to provide a comprehensive report of all major PLATO courseware projects. Reference to particular programs will be made only as they provide concrete instances of the points being made.

Diverse Goals of PLATO Authors

An important factor that influenced some authors in the development of PLATO courseware was the search for better ways to develop cognitive skills. An early nursing program on PLATO (Bitzer, 1969), for example, had as one of its goals to develop critical thinking using an inquiry or problem solving approach. Some work with inquiry training had been done (cf. Suchman, 1960) but there were few suggestions available for effective use of the technique. Moreover, much of the available research in programmed instruction dealt with transmission of information that was at a lower cognitive level. Few universal principles emerged, even from this research. For example, overt responses seemed to be an important factor in learning, but under certain conditions (Roderick and Anderson, 1968) students learned equally well without making such responses. Given that the needed research information was not available, PLATO provided a new opportunity for instructors whose goals included teaching complex concepts as well as developing processes and skills in the course of acquisition of knowledge.

Some authors felt that PLATO could do more than transmit knowledge as in textbooks or lectures. The idea is similar to that expressed by Olson and Bruner (1974) who stated that, "media converge as to the knowledge conveyed, but they diverge as to the skills they assume and develop." Consider, for example, a veterinary medicine simulation of a diagnostic situation. The student is given the case of a sick dog and must decide which laboratory tests he needs in order to make the diagnosis, while keeping the cost as low as possible. PLATO tells the student the results of each laboratory test he uses as well as its cost. The impact of being confronted with the total bill is more dramatic than the theoretical knowledge that some tests are more costly than others. The skills that are developed and applied in this lesson are different from those needed to derive this same kind of information from a textbook or lecture.

Other PLATO authors felt the need to shift some of the burden of routine classroom instruction away from the classroom thus freeing up class time for discussion of a more complex or enriching nature. For example, let the

computer provide the drills in Latin vocabulary so that more class time could be devoted to discussion about the history and culture of ancient Rome (Scanlan, 1971). In these applications, PLATO was intended to deal with a particular aspect of a larger body of instruction.

Still another approach was based on the idea that this was a new, undeveloped technology and one of the first missions of courseware should be to help provide an understanding of the interrelationships between PLATO, the student, and the instruction. Certainly PLATO provided a tight feedback loop for studying the learning process. The author could observe the student, obtain data on a lesson immediately, and very readily make modifications as required. Early lessons for elementary school children were developed with this concept in mind.

Yet one more point of view was taken by a few people in early lesson development. Theirs was a creative approach, not bound by the constraints of instructional objectives for the student. Their primary goal was to find out what they could get PLATO to do; let creativity and inspiration take them where it would. Educational applications would come later.

In summary, the educational potential of PLATO was viewed in different ways (cf. Olson, 1974). Some expected it to transmit the same knowledge as other media. One example is the elementary reading group who hoped to derive benefits from such PLATO features as its capacity to individualize and to automate record keeping. They were not seeking to transmit different knowledge from what other media offered; that is, their goal was simply to teach reading. Other authors expected that the interaction of the medium, the student, and the subject matter would provide something more than other media, such as new insights, special skills, or a more favorable student attitude.

It should also be noted that there was no one educational supervisor in the laboratory who urged a specific approach or philosophy in courseware development. Authors were free to follow their own systems, and they did.

Some Aspects of Courseware Development

What did actually happen in the process of courseware development? First, an explanation of what it entails to develop a piece of instruction for PLATO. Decisions need to be made about choice of topic, character of instructional design, integration of this part into the larger body of instruction, wording of directions and comments in response to the student's answers,

level of acceptable performance, and a basis for evaluation and validation. The task also involves programming the TUTOR language plus display and aesthetic considerations. It becomes apparent that designing a PLATO lesson requires the application of many skills.

Although there are some individuals who can handle all of these tasks, more frequently a group effort is necessary. But it isn't enough for a content specialist to hire a programmer to implement instruction on PLATO. One of the language professors, for example, wanted to use PLATO but didn't want to learn anything about programming in the TUTOR language. He found that he was unable to design PLATO lessons effectively because he did not have a feeling for the limitations and advantages of PLATO. He did not know what constituted good display techniques. His lack of familiarity with the programming language resulted in assigning a task which forced his programmer to write considerable amounts of special code. In a different situation, a programmer who had no teaching experience added displays and fancy graphics which, although attractive, were useless, boring, and somewhat abrasive to the students. Even if a PLATO curriculum is the responsibility of a coordinator who is knowledgeable in the many aspects of PLATO lesson design, the members of his team must also have some basis for communicating with each other (Grimes, 1973).

It also turns out that when trying a new instructional technique it may be most productive to do the heart of the lesson first. Detailed decisions on branching, response handling, and display design can not be made until experience is gained from preliminary trials. The impact of the material is not always the same on the terminal as it is on paper; difficulties that might arise in programming are not always apparent in advance; furthermore, on-line revision is so readily available that long term commitments are not essential. In fact, those who write up an entire program first before showing it to others or reviewing it critically themselves sometimes find they have wasted time because major sections must be redone because the lesson is unnecessarily elaborate, it is bogged down in too much detail, or has gone off on a tangent.

Sometimes an idea for a general plan is conceived, say an algorithm for a drill or asking questions that require a specific kind of answer judging. The most efficient way to produce such a program is first to try out specific instances on students and colleagues, and then perhaps take time off to

develop a tool--a code in a general form that will be reuseable within a lesson or for many lessons.

The long term impact of a series of PLATO lessons may give a different perspective on results than looking at the short term effects of each lesson separately. A chemistry professor (Smith, 1974) found that on PLATO, just as in other forms of instruction, very often a single isolated lesson on a topic wasn't as effective as a series of lessons. In the early elementary arithmetic, the children would work on a drill for only a short period of time in a single session, but they were willing to do the lesson again at succeding sessions. The nature of evaluation is also partly a function of long term effect. An individual lesson may not look as good or as bad in the context of a series of lessons as it does in isolation.

Sometimes student expectations affect lessons in unanticipated ways. For example, the author may intend the lesson to be only an introduction to an idea or a concept and provide a minimum amount of interaction, expecting that the student will use textbooks or other means to further his understanding. The student, however, may think that just because he got through the lesson, he really knows the material and there is no need for further study. Some students take extensive notes while working on the terminal, treating the content like a lecture. The point is that since PLATO is a new medium, variables in the affective as well as cognitive domain must be considered.

Generalizations

Are there any generalizations that can be drawn from these initial experiences? Can we now write a prescription for courseware design, making modifications and additions to other systems approaches that seem appropriate to the PLATO system? Do we want to write a prescription?

Based on extensive interviews with independent groups of authors, the most successful groups found that it is important for each member of the team to have some knowledge about all aspects of PLATO lesson design. But if a coordinator must hire a staff member with a limited background, teaching experience is more valuable than programming experience. Most groups agree that the best programmers are those who show enthusiasm and commitment to PLATO. They are considerably more productive than those for whom it is only a job. Even in the classroom, the attitude of instructors can affect the impact of a PLATO lesson. In one course, students could voluntarily attend review sessions on PLATO. One of the teaching assistants was a PLATO programmer

and enthusiastic about the system; 90% of the class came to use PLATO. The other teaching assistant was afraid of the system, and only 10% of his group showed up.

Although motivational considerations are important and PLATO lends itself to the creation of fancy displays and clever animations, very simple devices often prove to be satisfactory. In some cases it is an advantage to allow students to choose the topics they wish to try. In other cases it is beneficial to let them see a chart on their performance relative to the rest of the class. Instructor conferences in one class dropped to almost zero when this feature was provided. For the very youngest children, a ribbon on the display indicating good work proved to be most rewarding (Rothbart and Steinberg, 1971).

There is evidence that using student feedback to improve the quality of instruction results in more positive attitudes toward use of PLATO. Avner (1972) did a study of five courses taught for college credit. Each required a minimum of ten hours of PLATO contact. Each time the course was taught, authors received feedback from the students and revised on that basis. A general attitude item was administered over three successive semesters (and tryout revision cycles). It was initially on the positive side of neutral and showed an increasingly positive attitude toward PLATO. The probability of a trend equal to or better than that observed was less than .01.

Some procedural generalizations can also be stated. (1) It is sometimes profitable for the author to divert time from lesson development in order to develop a special piece of coding that can be re-used on many lessons, such as a special type of response judging. (2) Authors should work as students themselves to get the perspective of the student. (3) They should observe students working at the terminals. (4) Feedback is most accurately transmitted when done directly between the student and the author rather than through an intermediary. (5) Authors who keep alternative or "backup" instructional approaches in mind are in a position to be relatively flexible when lessons need revision.

We have also learned that there is a very special kind of psychology that accompanies involvement in PLATO authorship. The lessons tend to be viewed by their authors as works of art; they are as much a part of them as paintings must be to artists. Consequently beginning authors are particularly

reluctant to throw them out, even if student trials prove them to be ineffective. It is very difficult for an experienced teacher who is a beginning PLATO author to admit that after hours of careful planning and devotion to writing a lesson, it may in fact not be quite all that great. Willingness to revise lessons may depend, in part, on how much time it will take or on how readily the authoring language lends itself to the needs of the authors. PLATO authors often ask their colleagues to review their lessons. This may lead them to writing impressive lessons that satisfy or even dazzle their peers, but do not have the same effect on students.

Benefits and Pitfalls

One benefit that derives from the various approaches to instructional use of PLATO is that it provides an opportunity to test the reliability of observations or generalizations over a broad base. One can, therefore, transmit this information to new authors and have confidence that it will be applicable under a wide variety of conditions.

Another advantage is that the author need not put all of his eggs in the same basket. Thus the author need not be restricted to a long term commitment that proves to be less than satisfactory. He has the flexibility to be responsive to changes that are needed. During the course of development and student trials, he may gain new insights as a result of the complexity of interaction of the student with the lessons and PLATO. Presentations, formats, or even goals may be revised on the basis of these observations.

Courseware developers have been able to think in terms of what they would like the system to do for the students rather than how to make the instruction fit the constraints of the technology. This lends itself to a creative atmosphere and provides a fertile climate for imaginative departures from traditional instructional notions.

But the incremental process also has its pitfalls. One of these is that it lends itself to writing lessons that are exciting to create and to do but result in little learning. At the other extreme, with no strong guidelines, some authors write lessons that are neither interesting nor useful.

Another effect of an evolving system rather than a stable one is the difficulty in disseminating information to authors everywhere. Documentation tends to be only on PLATO rather than in hard copy. Authors must be willing to constantly make adaptations. There is also a tendency among authors not to document all changes as a lesson evolves.

Skinner's early admonitions about teaching machines are also applicable to PLATO. The kind of material used is indeed critical; presenting does not necessarily mean teaching. Based on experience, we know that there are some additional critical factors such as organizational procedures, staff requirements, and interaction effects of student and medium. It makes sense that this body of information should be transmitted and taken into account in further development of couseware. However, it has been our experience that some of the most creative and purposeful lessons were developed in an atmosphere that did not require strict adherence to a single approach. Developing PLATO courseware should probably be an artful blend of procedures that have been shown to be successful with the opportunity to make imaginative departures.

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